Cryptomare Delineations using Craters as Probes to Lunar Stratigraphy: Use of Multispectral Clementine Data as a Tool; I. Antonenko, J. W. Head, C. M. Pieters. Dept. Geol., Brown Univ., Providence, RI 02912 USA, irene_antonenko@brown.edu.

Hidden mare deposits, or cryptomare, present evidence of ancient mare volcanism [1], and thus merit further study. We have addressed issues of cryptomare identification [2], and presented techniques for determining cryptomare geometry using dark halo impact craters (DHCs) which punch through overlying ejecta to excavate underlying mare material [3]. These techniques have been applied to a study area on the western limb of the Moon, using rectified Earth-based telescopic images and Zond data. The resolution and coverage of these data sets, however, is fairly limiting. Furthermore, visual identification of DHCs requires that the soils developed on the crater ejecta be spectrally mature. The Clementine data set, with global coverage, improved resolution, and multiple channels, presents a new opportunity to expand our studies, allowing smaller and less mature craters to be considered.

As a test area, we chose a region of light plains in Schickard crater on the western limb of the Moon (Fig. 1). This area exhibits a variety of features including a large subdued crater, a dark halo crater in the south-west surrounded by a region of smooth, low albedo ejecta, and a large number of small, fresh craters. We prepared a Clementine frame of this area, working with 5 UVVIS bands, calibrating and registering the data as described in [4] to produce a single image cube. Ratios of the 415nm, 750nm, and 950nm filters were then obtained [4]. Figs 2 and 3 show 415/750nm and 750/950nm ratio images respectively, contrast stretched to show the highs (the checkered pattern in Fig 3 is an artifact of the compression algorithm this data was subjected to before transmission to Earth).

We are interested first in identifying the presence of a mafic component within the craters in our image, and second in determining whether it is basaltic in composition. The first part can be accomplished by comparing the 415/750nm and 750/950nm ratio images. The 415/750nm ratio measures the continuum slope steepness in the visible. Bright areas in Fig 2 represent flatter continuum slopes which generally indicate fresh or feldspathic materials. The 750/950nm ratio is an approximate measure of the strength of the ferrous absorption feature near 1µm. Bright areas in Fig 3 represent strong absorption features, indicating the presence of abundant mafic minerals or fresh materials [5]. Areas which are bright in Fig 3 but not in Fig 2 represent a strong absorption feature produced by iron bearing minerals and thus indicate a mafic component. Looking at Figs 2 and 3, we can see that the dark halo crater has a strong mafic component, many of the small craters in the north-west also have a strong mafic component, and surprisingly, only a portion of the wall of the large subdued crater appears to have a strong mafic component.

Our analysis can be extended by considering 5-channel spectra taken from key areas in the image. We collected average 3X3 pixel spectra for the locations shown in Fig 1. Representative spectra of fresh materials, gathered from the slopes of various small craters and in a traverse around the slopes of the large degraded crater, are shown in Fig 4. Craters whose spectra exhibit a ferrous absorption feature near 1 µm are interpreted as tapping high-Ca pyroxene-rich material indicating buried basalt (Fig 4A). Those that exhibit a shorter wavelength absorption or a very weak absorption are interpreted as tapping primarily highland material (Fig 4B). The combined analysis of spectra and ratio figures indicates that craters on the western side of the image tap into buried basalt and that the large subdued crater impacted the edge of this cryptomare deposit.

We used the spatial distribution of craters that exhibit basaltic properties to estimate the cryptomare boundary in this area. In Fig 5, we present a sketch map of the cryptomare extent for this frame. Areas where crater spectra indicate basaltic compositions (indicated by solid squares) are designated as cryptomare regions, areas where crater spectra indicate highland material (open squares) we designated non-cryptomare regions, areas where craters have ambiguous spectra, neither strongly mafic nor strongly feldspathic (half-filled squares), are marked as ambiguous. Confirmation of the estimated boundaries of large scale cryptomare deposits will be evaluated with analysis of independent contiguous frame sets.

Results of the spectral analysis can also be used to estimate the depth of the cryptomare deposit. The presence of basaltic material on the slopes of even the smallest craters in the north-west corner of the image (0.5 km in diameter) suggest the obscuring layer here is very thin, <50 m [3]. The largest crater exhibiting spectra with consistent basaltic characteristics is the dark halo crater in the south-west corner of the image. This 4.7 km diameter crater excavates basaltic material from a depth of approximately 500 m [3]. Thus, the cryptomare in this region must be at least 450 m thick.

The improved resolution and multispectral nature of the Clementine data set allows us to expand the repertoire of techniques available for determination of cryptomare characteristics. Spectral analysis can be used to determine the basaltic nature of fresh material on crater slopes. Analysis of these small, fresh craters can be used to delineate cryptomare boundaries.

Identification of basaltic materials in the smallest craters can help to constrain the thickness of the obscuring layer, thus improving overall cryptomare thickness estimates.

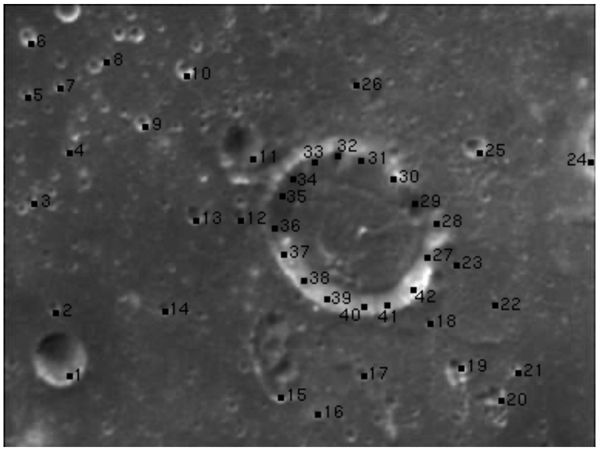

Figure 1: Blue 750 nm filter Clementine image of the test area, showing the locations of spot spectra.

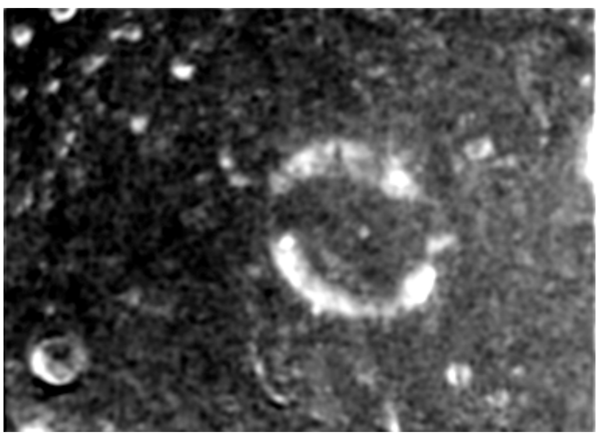

Figure 2: 415/750 nm ratio image of the test area.

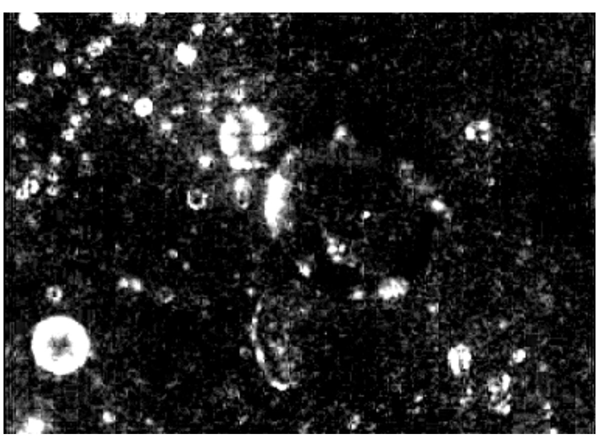

Figure 3: 750/950 nm ratio image of the test area.

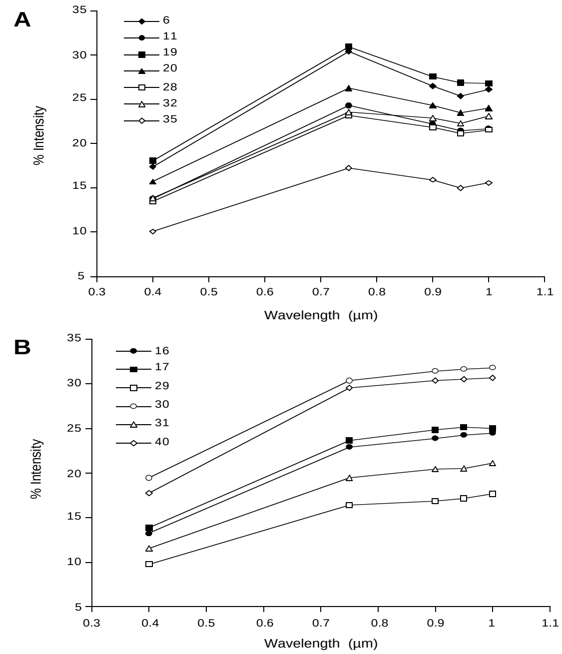

Figure 4: Representative spectra of fresh materials interpreted as indicating basalts and highland material B. Spectra locations are shown in Fig 1.

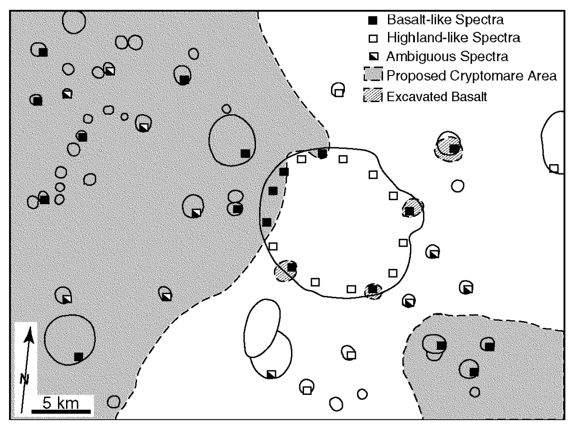

Figure 5: Sketch map of area, showing cryptomare boundaries and location of isolated patches of excavated basalt, determined from spectra and ratio images

References: [1] P. Schultz & P. Spudis, *PLPSC* 10, 2899, 1979; J. Bell & B. Hawke, *PLPSC* 12, 665, 1981. [2] I. Antonenko *et al.*, *EMP*, 69,141,1995. [3] I. Antonenko & J. Head, *LPSC* 25, 35, 1994; I. Antonenko & J. Head, *LPSC* 26, 47, 1995; I. Antonenko and J.W. Head, in preparation. [4] C.M. Pieters *et al.*, *Science* , 266, 1844, 1994; C.M. Pieters *et al.*, http//:www.planetary.brown.edu/ clementine/calibration.html, 1996. [5] E.M. Fischer and C.M. Pieters, *Icarus*, 1995; J.B. Adams and T.B. McCord, *Science*, 171, 567, 1971; C.M. Pieters *et al.*, *JGR*, E98, 17127, 1993.